Shallow Water RASP Upgrade

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ABSTRACT

The Range Dependent Active System Performance model (RASP) has been modified to function at higher frequencies in shallower water than its initial design specification. The major difficulties in the original version of the model were the control of the cubic spline fitting routines to the sound speed points, extension of attenuation coefficients to higher frequencies and the need to interface to Navy standard data bases (or models) for bottom loss calculations. These two areas of difficulty were overcome using a front end sound speed fitting algorithm based on cubic splines under tension to control the oscillations in the spline fits in the model, and subroutines to allow input of standard bottom loss curves.

The resulting modifications to the model created a model capable of predicting range dependent monostatic reverberation (with reasonable accuracy) at frequencies up to 10 kHz. The modifications did not address the broader problem of bistatic range dependent reverberation at high frequencies (or in shallow water), or the problem of "energy splitting loss" on predicted target returns.

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Shallow Water Range Dependent Active System Model (RASP) Upgrade

INTRODUCTION

The requirement to improve active systems modeling capability in shallow water presents a new set of challenge to the active system models that are currently in use. In this technical note the modifications that have been made to the Range Dependent Active System Performance model (RASP) will be documented. For technical details on the RASP model the reader is referred to Franchi et al. (1984).

Primarily the modifications are made to increase the maximum frequency at which the model can be operated by modifying the attenuation coefficient to be correct at higher frequencies, and by introducing the High Frequency Bottom Loss (HFBL) curves into the model. Another critical area of modification was to introduce a method that would limit the size of extraneous inflection points in the sound speed profile used by the ray tracing model.

SOUND SPEED FITTING MODIFICATION

RASP converts pairs of depth, velocity to continuous functions via the technique of cubic spline (Cornyn, 1973). The cubic spline function produces the smoothest interpolant to a set of points that pass through the points in the sense that the strain energy associated with the curve is minimized (de Boor, 1978). It does however, produce extra minima and maxima by failing to preserve the convexity of the set.

There are two approaches that could have been taken to overcome this problem. The first approach is to change the fitting routine in the model to one which is more robust with respect to extraneous inflection points. The second approach is to modify the input profiles such that the extraneous inflection points are minimized. The second approach was selected, primarily to minimize the amount of time necessary to introduce the change.

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The cubic spline under tension (Cline, 1974) produces a fitted curve that maintains the original convexity of the set. Therefore, the input sound speed profiles were fitted using a cubic spline under tension, and resampled for subsequent entry into the RASP model. It was found that if the original points were retained along with the densest possible sample, that the extraneous inflections were reduced to a point where their effect on calculations were minimized.

ATTENUATION FUNCTION

The absorption coefficient computed by RASP is ordinarily the Thorp equation (Cornyn, 1973). This relationship is valid for the frequency regions between approximately 100 Hz to 3 kHz. In order to extend the absorption coefficient to higher frequencies it is necessary to replace the Thorp equation by a different equation. The equation selected for this extension is the Hall-Watson equation (Kirby, 1983). This equation is a function of both frequency and water temperature. The Hall-Watson equation is given as:

$$A = (1.776\ f^{1.5} + f^5\ [\ ((0.65053\ f_T)/(f^2 + f_T^2) + 0.026847/f_T]/(32.768 + f^3)$$

$$\text{where } f_T = 21.9 \times 10^{(30T+102)/(5T+2297)}$$

and f is the frequency in kHz, f_T is the relaxation frequency in kHz, A is the attenuation in dB per kiloyard, and T is the temperature in degrees Fahrenheit. The temperature selected for use with the attenuation coefficient is the temperature at the depth of interest. That is if a surface file is being processed for attenuation, then the surface temperature will be used. Assuming that the salinity is 35 ppt, then the sound speed as a function of temperature is given by (Clay and Medwin, 1977)

$$S = 1449.2 + 4.6\ T - .055T^2 + .00029T^3 + .016Z,$$

where S is the sound speed in m/sec, T is the temperature in degrees Centigrade, and Z is the depth in meters. For a given depth this formula can be solved for the temperature that gives the sound speed observed, and that temperature converted by the well known conversion formula.

BOTTOM LOSS

RASP requires that bottom loss information must be in the form of bottom loss versus grazing angle. There are two standard methods of specifying bottom loss. These are the Low Frequency Bottom Loss (LFBL) parameters, and the HFBL curves. The LFBL parameters are usually converted into bottom loss versus grazing angle using the PREP-PE program, or some similar program that implements the conversion. Therefore, it must be assumed that the user has access to these routines. The HFBL curves have been implemented via a series of common blocks that hold the coefficients for the curves, and a query to the user for the province for which the bottom loss must be known. This change is reflected in the annotated list of RASP input question presented in appendix A, and some recommended input values in appendix B.

SAMPLE RESULTS

In this section the results of modeling the reverberation at four shallow water sites will be presented. At each site the results of a single frequency band is presented.

The first site presented is taken from Urick (1969). The water depth is assumed to be constant 200 ft, with a source depth of 60 ft, and a receiver depth of 80 ft. The source is a SUS Mark 61. The sound speed profile as extracted from the measurements is given by:

Depth (ft)	Sound Speed (ft/sec)
0	5051
120	5053
200	5011

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The bottom in the area was a mixture of coral, sand, and shell. The wind during the test ranged from 0 to 7 kt, with waves around 1 ft. Figure (1) shows the measured versus predicted reverberation for the octave band from 3.2 Hz to 6.4 kHz.

Figure 1. Plot of measured reverberation and predicted reverberation versus time for the first site (octave band from 3.2 kHz to 6.4 kHz).

The second site presented is taken from Urick (1971). The water depth is assumed to be constant 125 ft, with a source depth of 60 ft, and a receiver depth of 90 ft. The source is a SUS Mark 61. The sound speed profile as extracted from the measurements is given by:

Depth (m)	Sound Speed (m/sec)
0	1539.8
20.7	1540.2
23.5	1531.0
38.1	1531.2

The bottom in the area was a clayey silt. The wind during the test ranged from 5 to 15 kt, with waves around 3 ft. Figure (2) shows the measured versus predicted reverberation for the octave band centered at 2 kHz.

Figure 2. Plot of measured reverberation and predicted reverberation versus time for the second site (octave band centered at 2 kHz).

The third site presented is taken from Erskine et al. (1990). The water depth is assumed to be constant 200 m, with a source depth of 60 ft, and a receiver depth of 300 ft. The source is a SUS Mark 82. The sound speed profile as extracted from the measurement is given by:

Depth (m)	Sound Speed (m/sec)
0	1492.0
20	1493.0
30	1479.0
66	1471.0
100	1469.0
198	1470.0

There was no bottom information available, thus a typical BLUG type bottom loss curve typifying low bottom loss was used. The wind during the test ranged from 2 to 9 m/sec during the test. Figure (3) shows the measured versus predicted reverberation for the octave band running from 400 Hz to 800 Hz.
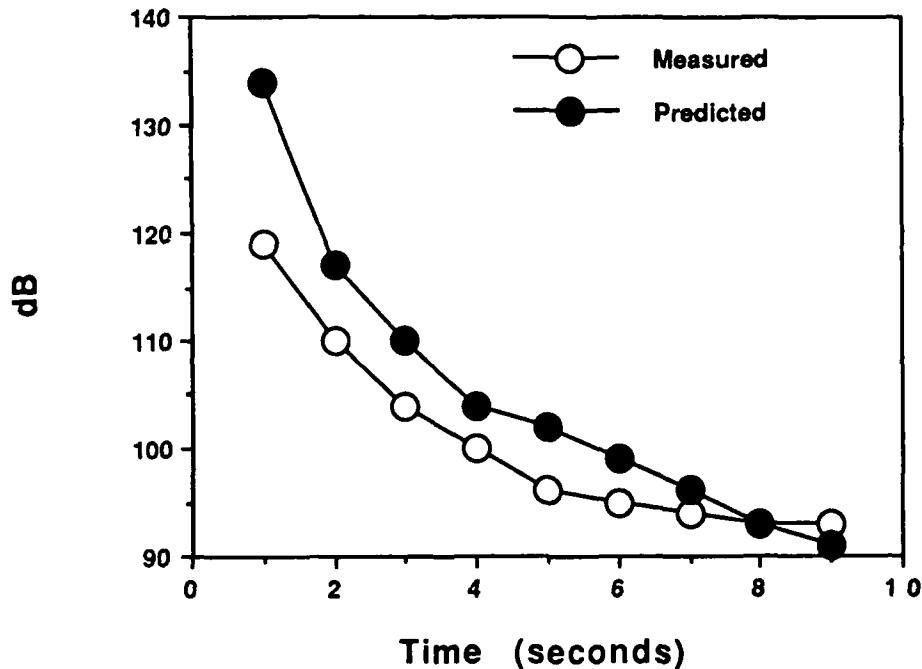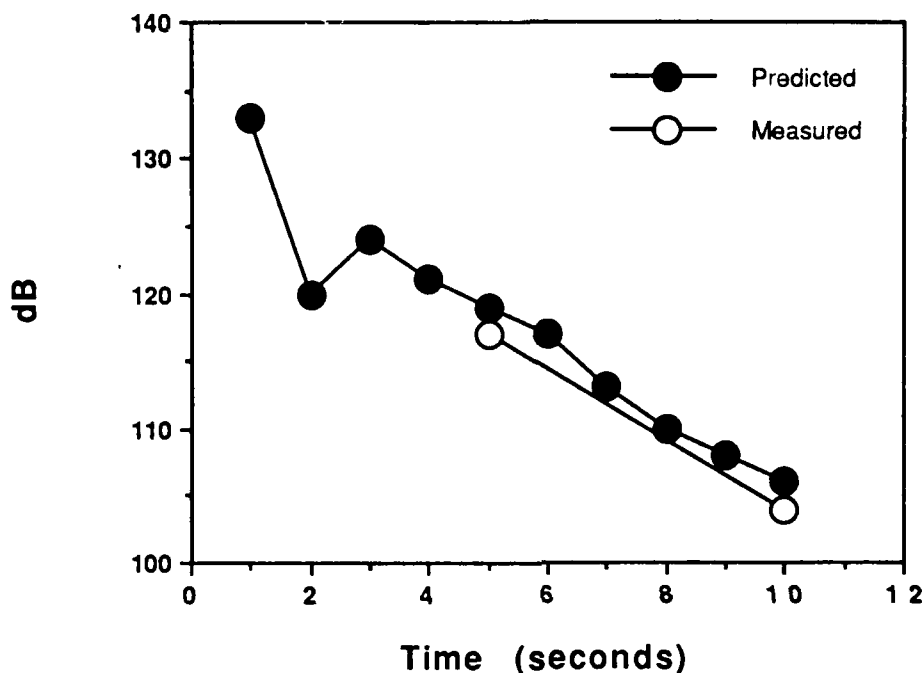

Figure 3. Plot of measured reverberation and predicted reverberation versus time for the third site (octave band from 400 Hz to 800 Hz).

The third site presented is taken from Browning (1971). The water depth is assumed to be constant 325 ft, with a source depth of 175 ft, and a receiver depth of 175 ft. The source is a SUS Mark 61. The sound speed profile as extracted from the measurements is given by:

Depth (ft)	Sound Speed (ft/sec)
0	4782
30	4783
50	4785
84	4718
325	4724

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The bottom at the site was a silt overlying bedrock. The sea surface was calm. Figure (4) shows the measured versus predicted reverberation for the octave band running from 3.2 kHz to 6.4 kHz.
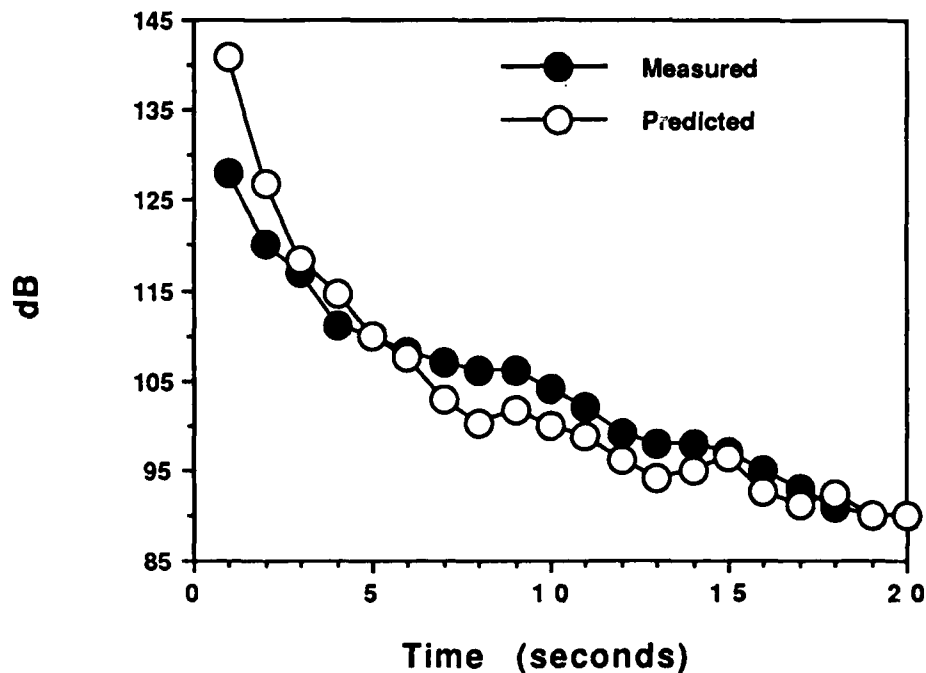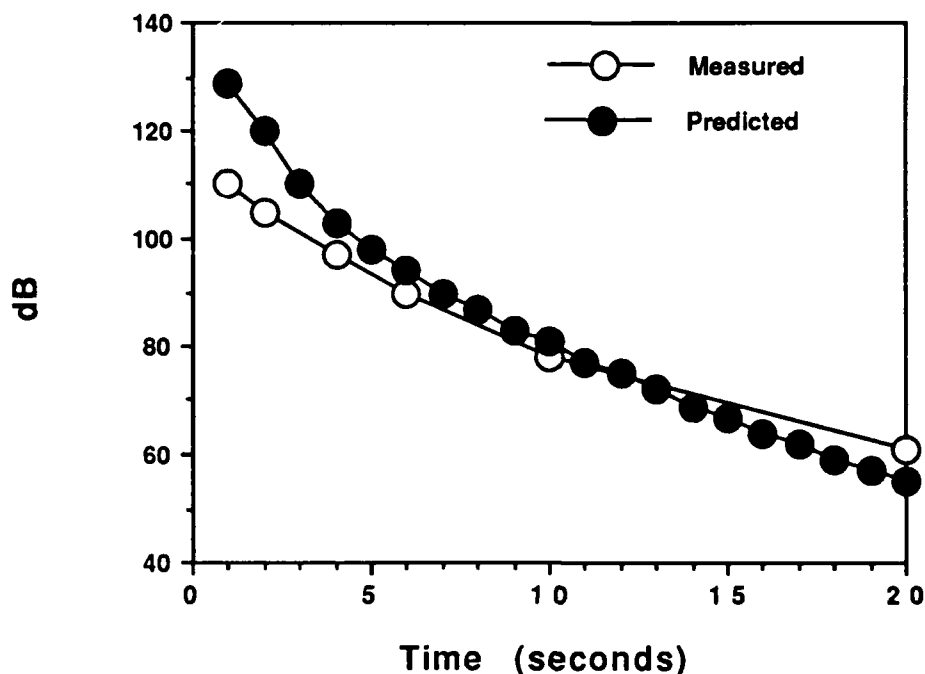

Figure 4. Plot of measured reverberation and predicted reverberation versus time for the fourth site (octave band from 3.2 kHz to 6.4 kHz).

For each of the four reverberation measurements shown the agreement between the modeled results, and the measured results was good. There is a tendency to predict levels that are initially too high. This problem needs to be addressed.

SUMMARY

This technical note has demonstrated that with a few relatively simple modifications, the RASP model can function adequately in shallow water environments as far as reverberation prediction is concerned. Target echo level has not been addressed in this study nor was volume reverberation.

Volume reverberation was addressed for lower frequencies for CST. Results from studies on modeling active systems in shallow water (Bell and Fisch, 1990) reveal that it may be necessary to either include a loss mechanism for energy splitting due to multipath returns, or to calculate the target returns based on multipath (rather than two way transmission loss) method.

REFERENCES

Browning, David G. (1971). Project CANUS: Sound Propagation and Reverberation Measurements in Hudson Bay. Naval Underwater Systems Center, New London, CT NUSC Report 4221.

Bell, Thaddeus G. and Norbert P. Fisch (1990). Modeling Signal-Processing Degradation for AN/SQQ-891 Active-Sonar Operations in Shallow Water Final Report on Baseline Results. Prepared for SPAWAR 315.

Clay, Clarence S. and Herman Medwin (1977). Acoustical Oceanography Principles & Applications. Wiley Interscience Publications, 544 pp.

Cline, A. (1974). Scalar- and planar-valued curve fitting using splines under tension. Comm. ACM, 17 218-223.

Cornyn, John J. (1973). Grass: A Digital-Computer Ray-Tracing and Transmission-Loss-Prediction System. Naval Research Laboratory, Washington, DC, NRL Report 7621.

de Boor, Carl (1978). A Practical Guide to Splines. Applied Mathematical Series NO. 27, Springer Verlag, 392 pp.

Erskine, F.T., J.M. Berksen, and P.M. Ogden (1990). Airborne Acoustic Measurments in Shallow Water. Naval Research Laboratory, Washington, DC, NRL Report 9286 (DRAFT).

Franchi, E.R., J.M. Griffin, and B.J. King (1984). NRL Reverberation Model: A Computer Program for the Prediction and Analysis of Medium- to Long-Range Boundary Reverberation. Naval Research Laboratory, Washington, DC, NRL Report 8721.

Kirby, W.D. (1983). Technical Description For the Ship Helicopter Acoustic Range Prediction System (Sharps III). SAI 83-1011-WA.

Urick, R.J. (1969). Acoustic Observations At A Shallow Water Location Off The Coast Of Florida. Naval Ordnance Laboratory, Silver Spring, MD, NOLTR 69-90.

Urick, R.J. (1971). Airborne Measurements Of Shallow Water Acoustics At Various Shallow Water Locations Off The Eastern And Gulf Coasts Of The United States. Naval Ordnance Laboratory, Silver Spring, MD, NOLTR 71-4.

APPENDIX A

This appendix lists a annotated version of the inputs that are required to run this version of the Range Dependent Active System Performance model (RASP). The list is complete, but the annotation is not all inclusive. Thus, some thought and practice will be required of any potential use of this version of the model.

Inputs for Program TAUNT

This section describes the inputs for program TAUNT. TAUNT takes as input the sound speed profiles from some source and generates a taunt version of the profiles that will remove most (if not all) of the false minima and maxima than can occur under cubic spline fitting. The output file from TAUNT is a sound speed input file useable by program PROFIL.

1. ENTER THE FILE NAME OF SOUND SPEED DATA

The desired input is the name of a file containing range ordered sound speed profiles. The format of the file is:

      (Range)   (Number of depth sound speed pairs)

followed by Number of pairs of (depth (m)) (sound speed (m/sec))

There may be up to 100 profiles along any one track, with each profile consisting of up to 50 depth sound speed pairs.

2. ENTER THE FILE NAME FOR OUTPUT SOUND SPEED DATA

The desired input is the name of a file containing range ordered sound speed profiles. The format of the file is:

      (Range)   (Number of depth sound speed pairs)

followed by Number of pairs of (depth (m)) (sound speed (m/sec))

There may be up to 100 profiles along any one track, with each profile consisting of up to 50 depth sound speed pairs. This file is compatible with the input requirements for program PROFIL.

Inputs for Program PROFIL

This section describes the inputs for program PROFIL. PROFIL takes as input user specified bathymetric, and sound speed tracks, and generates a print file, a data file for the program RAYACT, and the plots specified by the user. The user inputs for PROFIL are listed below as they appear when executing the program.

1. ENTER THE TITLE FOR THIS RUN (UP TO 68 CHARACTERS)

The is an alphanumeric identifier that will appear on the print file and the composite environment plot (if specified).

2. ENTER THE NAME FOR THE PRINT FILE

This is the file name assigned to the output print file generated by the program, it may be any unique valid name.

3. ENTER THE NAME FOR THE OUTPUT ENVIRONMENT FIELD

This is the file name assigned to the output data file generated by the program. This file contains information that is necessary to execute the RAYACT ray tracing program.

4. DO YOU WISH A COMPOSITE ENVIRONMENT PLOT? 1=YES, 0=NO
   (COMBINED BOTTOM AND SS PROFILES)

If a plot of the bathymetric track and sound speed profiles are desired, selecting this option will cause a plot of the environment to be generated.

5. DO YOU WISH A PLOT OF SOUND SPEED CONTOURS? 1=YES, 0=NO

Selecting this option will cause a contour plot of the sound speed environment to be generated. In general this plot is useful only if the sound speed environment is range dependent.

6. DO YOU WISH A PLOT OF SELECTED PROFILES? 1=YES, 0=NO

This option will allow the users to plot selected sound speed profiles individually.

7. ENTER FILE NAME OF THE BATHYMETRIC DATA

The desired input is the name of a file containing range ordered pairs consisting of range followed by depth. The range can either be in kilometers, or in nautical miles. The depth must be in meters. The format is free field.

8. ENTER THE CODE OF THE BOTTOM RANGE UNITS - 0=KM, 1=NM

The proper response to this question is the range units appropriate to the input bathymetric track.

9. ENTER THE FILE NAME OF SOUND SPEED DATA

The desired input is the name of a file containing range ordered sound speed profiles. The format of the file is:

(Range)   (Number of depth sound speed pairs)

followed by Number of pairs of (depth (m)) (sound-speed (m/sec))

There may be up to 100 profiles along any one track, with each profile consisting of up to 50 depth sound speed pairs.

10. ENTER THE CODE OF THE PROFILE RANGE UNITS 0=KM, 1=NM

The proper response to this question is the range units appropriate to the input sound speed track.

11. OPTION TO PLOT INDIVIDUAL PROFILES HAS BEEN SELECTED
    ENTER DO LOOP PARAMETERS FOR SELECTING PROFILES TO
    BE PLOTTED - - NS, NE, NINC

OPTIONAL This query will arise only when individual profile plotting has been selected. The inputs are the standard inputs for a Fortran loop, with the exception that NINC must be specified. The standard order for a Fortran loop is starting number, ending number, and loop increment.

Inputs for Program RAYACT

This section describes the inputs for program RAYACT. RAYACT takes as input the environmental file generated by program PROFIL, user bottom loss specification, source depths, target depths to produce output data files, user specified print files, and the plots specified by the user. The user inputs for RAYACT are listed below as they appear when executing the program.

1. ENTER TITLE FOR RUN (UP TO 68 CHARACTERS)

The is an alphanumeric identifier that will appear on the print file and the ray trace plot (if specified).

2. ENTER THE NAME OF THE OUTPUT PRINT FILE

This is the file name assigned to the output print file generated by the program, it may be any unique valid name.

3. DO YOU WISH A PRINT FILE OF RAY STATISTICS? N=YES, 0=NO
N=STATUS PRINTED FOR EVERY Nth RAY

Specifying a print file of the ray statistics will give a print file showing the statistics (arrival angle, travel time, etc.) for each ray for all boundary interactions, and (if target depths are specified) target depth interactions.

4. ENTER NAME FOR PRINT FILE FOR RAY STATISTICS

OPTIONAL This is the file name assigned to the output ray statistics print file generated by the program, it may be any unique valid name.

5. ENTER FILE NAME OF INPUT ENVIRONMENT FIELD

Enter the file name of the PROFIL output file created using the sound speed field, and bathymetry that is desired.

6. ENTER SOURCE DEPTH (M)

Enter the depth in meters of (a) the source if the ray trace originates from the source location, or (b) the receiver if the ray trace originates from the receiver location.

7. ENTER UP THE 3 TARGET DEPTHS(M): 0 TO STOP

Enter the depths of up to three targets in meters. If fewer than three target depths are specified the the last specified depth must be 0.

8. ENTER RAY TRACING PARAMETERS
RINIT(KM), RMAX(KM), NODUC, NBB,
-TMAX(SEC), BLMAX(DB), MAXORD

Enter, in order, RINIT the initial range of the ray trace in kilometers (normally zero), RMAX the final range of the ray trace in kilometers (normally 20 percent beyond the maximum range of interest), NODUC a control variable that when set to zero uses the default linear interpolation between sound speed minimums in adjacent sound speed profiles, otherwise a location interpolation between adjacent profiles at the same depth is used (normal value is zero), NBB the number of bottom bounces that a ray may take (maximum value is 98), TMAX is the maximum time a ray is allowed to propagate (if set to zero the maximum range determines the travel time), BLMAX is the maximum bottom loss that a ray is allowed to accumulate before being terminated (the default value is 175), and MAXORD is the number of turning points (bottom bounces, surface bounces, and refractive turning points) that a ray is allowed, the maximum number is 196.

9. DO YOU WISH TO REDEFINE DEFAULT RAY ITERATION PARAMETERS?

If you do not wish to redefine the default ray iteration parameters then enter 0.

10. ENTER ITERATION PARAMETERS
DELMIN, DELMAX, HITDEL, VFAEPS, DELSMX

OPTIONAL DELMIN is the minimum range step for a ray, DELMAX is the maximum allowable range step for a ray, HITDEL is the tolerance for

boundary or target depth interaction, VFAEPS is the maximum allowable error in sound speed estimation, and DELSMX is the maximum allowable change in the sine of the ray.

11. RAY LAUNCH ANGLES ARE SPECIFIED BY FANS
    (INTERVALS) OF EQUISPACED ANGLES. ANGLES
    ARE MEASURED POSITIVE DOWN AND IN DEGREES
    ENTER NO. OF FANS

The rays that are traced by this version of RAYACT are specified by the user. They are specified as ray fans, that is fans defined by minimum, incremental, and maximum angles. Inside each ray fan the ray angular spacing is constant. Approximately 1000 rays can be specified.

12. FAN 'I' ANGST, ANGINC, ANGEND

This entry will be entered the number of times that is specified in the previous entry. Basically the input is the minimum angle, the incremental angle, and the maximum angle for each fan. The fans start from -89.6 degrees and go to 89.6 degrees with a minimum increment of 0.1 degree. Do not specify the same angle more than once.

13. ENTER THE SOURCE OF BOTTOM LOSS FOR COMPUTATION
    1 = BOTTOM LOSS TABLE, 2 = NOO CURVES.

Two choices are given for bottom loss, either a table of values can be entered into the program via a file, or a NOO province can be specified.

14. ENTER THE NAME OF THE BOTTOM LOSS FILE

If a bottom loss table is specified, then the program will expect a file name containing the table in the format
    number of tables (maximum = 4)
    number of entries in table, maximum range of table
    grazing angle, bottom loss (number of entries times)

15. ENTER THE HIGH FREQUENCY BOTTOM LOSS PROVINCE

If the NOO curves are specified, then a single province (1-9) is specified for the bottom loss.

16. DO YOU WISH A PLOT OF RAYPATHS? +N,-N=YES, 0 = NO

  EVERY Nth RAY PLOTTED

  N<0: WILL INPUT MIN, MAX ANGLE (DEF TO -20, +20)

  N controls the number of rays plotted. If N is zero then no rays are plotted, N = 1 implies plotting every ray, N = M implies every mth ray will be plotted.

17. PLOT OF RAY PATHS HAS BEEN REQUESTED

  ENTER MIN ANGLE, MAX ANGLE, R-AXIS(IN), DP-AXIS(IN)

  MAX RANGE(KM), MAX DEPTH(M)

  The angle entries are in degrees, if n (the control for the number of lines) is negative the numbers entered will be used. R-AXIS(IN) is the length of the range axis in inches, DP-AXIS(IN) is the length of the depth axis in inches. MAX RANGE(KM) is the maximum range to which to plot the ray traces, and MAX DEPTH(M) is the maximum depth of the ray trace to be shown on the plot.

18. DO YOU WISH TO SAVE SURFACE ENCOUNTERS? 1=YES, 0=NO

  If you wish to calculate surface reverberation you must save the surface encounters.

19. ENTER THE NAME FOR STORING SURFACE ENCOUNTERS

  OPTIONAL Will be queried only if answer to previous question is yes. This is the file name assigned to the output data file generated by the program. This file contains information that is necessary to execute the RTHETA program.

20. DO YOU WISH TO SAVE BOTTOM ENCOUNTERS? 1=YES, 0=NO

  If you wish to calculate bottom reverberation you must save the bottom encounters.

21. ENTER THE NAME FOR STORING BOTTOM ENCOUNTERS

  OPTIONAL Will be queried only if answer to previous question is yes. This is the file name assigned to the output data file generated by the

program. This file contains information that is necessary to execute the RTHETA program.

22. DO YOU WISH TO SAVE TARGET DEPTH ENCOUNTER? 1=YES, 0=NO

OPTIONAL If a target depth has been specified then you may decide to save or discard the target depth crossing information .

23. ENTER THE NAME FOR STORING DEPTH ENCOUNTERS

OPTIONAL Will be queried only if answer to previous question is yes. This is the file name assigned to the output data file generated by the program. This file contains information that is necessary to execute the RTHETA program.

Inputs for Program RTHETA

This section describes the inputs for program RTHETA. RTHETA takes as input a ray trace file (created by RAYACT) user specified frequency and beam pattern, and generates a print file, a data file for the programs REVERB, or TLVSR and the plots specified by the user. The user inputs for RTHETA are listed below as they appear when executing the program.

1. TYPE TITLE OF JOB (UP TO 68 CHARACTERS)

The is an alphanumeric identifier that will appear on the print file and the composite environment plot (if specified).

2. ENTER NAME FOR PRINT FILE

This is the file name assigned to the output print file generated by the program, it may be any unique valid name.

3. ENTER NAME OF INPUT DATA FILE FROM RAYACT

This is a file created by program RAYACT, it can be either a ray trace file for bottom, surface, or target depth interaction.

4. DO YOU WISH A PLOT OF ORDER CONTOURS? 1=YES, 0=NO

This is the option for generating a range versus launch angle plot.

5. ENTER PLOTTING PARAMETERS:

RNGAX(IN), RMIN(KM), RSTEP, RMAX

ANGAX(IN), ANGMN(DGS), ANGSTEP, ANGMX

OPTIONAL If plot is selected then this question appears. RNGAX(IN) is the length of the range axis in inches, RMIN(KM) is the minimum range to plot, RSTEP is the incremental label range, and RMAX is the maximum range to plot. ANGAX(IN) is the length of the angle axis in inches, AGMN(DGS) is the minimum angle to appear on the plot, ANGSTEP is the incremental angle for labeling purposes, and ANGMX is the maximum angle to appear on the plot.

6. ENTER KFRQ, KBP, IFOUT, MINO, MAXO, IFANG, IFDEL

KFRQ is the acoustic frequency in hertz, KBP is the number of elements in the vertical array (1 is omnidirectional, and 0 means a user supplied beam pattern will be read in), IFOUT is the type of data file created, 0 implies no data file, 1 implies a ray averaged output file, and 2 implies a caustically corrected output file, MINO is the minimum order to calculate, MAXO is the maximum order to calculate (MINO is 1 for surface or targets, and 2 for bottom, while MAXO has a maximum value of 120), IFANG equals 1 implies than a range of angles (not the full fan) is to be processed, and IFDEL equals 1 implies that a launch angle is to be deleted.

7. ENTER NAME FOR OUTPUT DATA FILE
                    FOR INPUT TO TLVSR, OR REVERB

OPTIONAL This is the file name assigned to the output data file generated by the program. This file contains information that is necessary to execute the TLVSR or REVERB programs.

8. ENTER ANGMIN, ANGMAX (DEGS) OF LAUNCH-ANGLES TO PROCESS

OPTIONAL Enter the minimum and maximum launch angles to process.

9. ENTER ANGLE (DEGS) TO DELETE

OPTIONAL Enter the launch angle to delete.

10. ENTER VERTICAL PHONE SPACING OF ARRAY (WAVELENGTHS), AND
DEGREES OF TILT FROM HORIZONTAL (+ IS DOWN): SP, TILT

OPTIONAL Enter the phone spacing is degrees, and the tilt of the array in degrees. This option assumes that the phones are equispaced, and equi-weighted.

11. ENTER NAME OF INPUT FILE CONTAINING BEAM PATTERN

OPTIONAL Enter the name of the file containing the beam pattern you wish to use. The beam patterns contain 181 values (in dB space) one for each vertical angle from 90 degrees up to 90 degrees down.

Inputs for Program TLVSR

This section describes the inputs for program TLVSR. TLVSR takes as input an output file generated by program RTHETA, and produces a transmission loss versus range and optional plots, and vertical arrival structure as function of range. The transmission loss files from the source to target, and receiver to target are used in ACTENV to produce echo level.

1. ENTER TITLE FOR THIS RUN (UP TO 68 CHARACTERS)

The is an alphanumeric identifier that will appear on the print file and the transmission loss plot (if specified).

2. ENTER IFPRT, IFPLT, IFOUT, IFARR

The symbols IFPRT, IFPLT, IFOUT, IFARR are integer variables that have the value yes when set to a 1, and no when set to zero. IFPRT asks if a print file is desired, IFPLT asks if a plot is desired. IFOUT asks if an output file (for use in ACTENV) is desired, and IFARR asks if the vertical arrival structure is to be printed along with the transmission loss.

3. ENTER NAME FOR PRINT FILE

This is the file name assigned to the output print file generated by the program, it may be any unique valid name.

4. ENTER NAME OF INPUT FILE FROM RTHETA

This is the file name of the range versus launch angle data file created by the program RTHETA.

5. ENTER NAME OF OUTPUT FILE

This is the file name assigned to the output data file generated by the program. This file contains information that is necessary to calculate a target echo level using ACTENV.

6. ENTER RGMN(KM), RINC(KM), RGMX(KM)

Enter the minimum range, incremental range, and the maximum range for which the transmission loss is to be calculated. Note the maximum number of ranges for which transmission loss can be calculated is 400.

7. ENTER MAXIMUM NUMBER OF ARRIVALS TO BE FOUND
   AT EACH RANGE
   *** DEFAULT AND MAXIMUM ALLOWABLE = 48.

OPTIONAL IFARR is assigned the value 1. Up to 48 arrivals at each range can be printed, if you desired less than 48 then enter that number.

8. ENTER PLOTTING PARAMETERS:
   XAXIS(IN), RGMN(KM), RINC(KM), RGMX(KM)
   YAXIS(IN), TLMIN(DB), DBINC(+DB), TLMAX(DB), DELY(+DB)

OPTIONAL IFOUT is assigned the value 1. XAXIS(IN) is the length of the range axis in inches, RGMN(KM) is the minimum range for which transmission loss is to be plotted (in kilometers), RINC(KM) is the incremental range for labeling (in kilometers), RGMX(KM) is the maximum range to be plotted. YAXIS(IN) is the length of the transmission loss axis in inches, TLMIN(DB) is the minimum transmission loss to be plotted, DBINC(DB) is the incremental loss value for labeling, TLMAX(DB) is the maximum transmission loss to be plotted, and DELY(+DB) is the span in dB of the transmission loss (if TLMIN, TINC, and TLMAX assigned then this value can be set to zero).

Inputs for Program REVERB

This section describes the inputs for program REVERB. REVERB takes as input output files generated by program RTHETA, user specified system characteristics, and scattering strengths. REVERB generates a print file and a data file for the program ACTENV. The user inputs for REVERB are listed below as they appear when executing the program.

1. ENTER TITLE FOR THIS RUN (UP TO 68 CHARACTERS)

The is an alphanumeric identifier that will appear on the print file and the composite environment plot (if specified).

2. ENTER FILE NAME FOR PRINT FILE

This is the file name assigned to the output print file generated by the program, it may be any unique valid name.

3. ENTER KEY FOR TYPE OF CALCULATIONS

KEY=1   MONOSTATIC
KEY=2   QUASI-MONOSTATIC
KEY=3   BISTATIC

Enter the proper key for the type run being made. If the source and receiver are identical in type, depth, and location, then monostatic is to be used. If the source and receiver only vary in depth, or type then quasi-monostatic. If bistatic is specified, then the run must be range independent.

4. ENTER NVERT, MXHITS, MXHITR

NVERT is the number of times that the vertical distribution of reverberation is to be written (if NVERT is greater than or equal to zero), if negative then the vertical distribution of reverberation is written out at equally spaced times specified by the user. MXHITS is the number of hits (or total arrivals) in a grid space that are allowed from the source, and MXHITR is the number from the receiver.

5. ENTER RMINS, RINC, RMAX (KM)

Enter the minimum, incremental, and maximum range from the source in kilometers.

6. KEY = 3 (BISTATIC CASE)
    ENTER RMINR, MRAXR, SEP (KM)
    OPTIONAL Enter the minimum and maximum range from the receiver. If the minimum range from the source is zero, then the receiver minimum range cannot be zero. SEP is the source receiver separation in kilometers.

7. ENTER DURATION OF CW PULSE, SEC
    The pulse duration in seconds.

8. ENTER INITIAL , TINC, AND FINAL TIMES OF REVERB ENVELOPE
    The times for which the envelope is to be calculated, in seconds.

9. ENTER ANGLES FOR VER. DIST. OF REVERB:
        THETA1, DTHETA, THETA2
    OPTIONAL If NVERT is not zero then the vertical reverberation as a function of time is specified. Enter the minimum, incremental, and maximum angles for which reverberation is to be calculated. (The limit is 181 bins, thus -90, 1, 90 specifies all angles in 1-degree bins).

10. ENTER 'NVERT' TIMES TO FIND VERT REV DIST
    OPTIONAL If NVERT is positive then you must specify NVERT times for which vertical distribution of reverberation is to be output.

11. ENTER TIMES TO FINE VERT REV DIST
        TVERT1, DTVERT, TVERT2
    OPTIONAL If NVERT is negative then you specify the initial, incremental, and final times to output vertical distribution of reverberation (in seconds).

12. ENTER FILE NAME FOR SOURCE CONTOURS FROM RTHETA
    Input the source output file from RTHETA.

13. ENTER NUMBER OF BOTTOM BACKSCATTER TYPES TO BE USED
     The limit is four backscattering types.

14. ENTER 'NSCAT' BACKSCATTER TYPES ALONG WITH
    RANGE OUT TO WHICH KSCAT WILL BE USED.

FOR BOTTOM

     KSCAT=FLAG INDICATING TYPE OF BOUNDARY BACKSCATTERING
      MODEL WILL BE USED
        -1=UNIT BACKSCATTERING FOR ALL ANGLES
         0=TABLE OF BACKSCATTERING MODEL TO BE READ IN
         1=INTERNAL NRL BACKSCATTERING MODEL-USED
         2=FREQUENCY-SCALING OF NRL MODEL
         3=STANDARD MODEL USED
         4=URICK ROCK BOTTOM DATA USED
         5=URICK SAND BOTTOM DATA USED
         6=URICK SILT BOTTOM DATA USED
         7=URICK CLAY BOTTOM DATA USED

13. ENTER NUMBER OF SURFACE BACKSCATTER TYPES TO BE USED

14. ENTER 'NSCAT' BACKSCATTER TYPES ALONG WITH
     RANGE OUT TO WHICH KSCAT WILL BE USED.

FOR SURFACE

     KSCAT=FLAG INDICATING TYPE OF BOUNDARY BACKSCATTERING
      MODEL WILL BE USED
        -1=UNIT BACKSCATTERING FOR ALL ANGLES
         0=TABLE OF BACKSCATTERING MODEL TO BE READ IN
         1=INTERNAL NRL BACKSCATTERING MODEL-USED
         2=FREQUENCY-SCALING OF NRL MODEL
         3=STANDARD MODEL USED

15. ENTER BOTTOM BACKSCATTER TYPE, MAX RANGE.

For bottom backscattering enter type -1 through 7, along with the maximum range in kilometers.

16. ENTER SS0, SS, WS, WH FOR STANDARD SCATTERING MODELS

OPTIONAL For surface reverberation SS0 is the scattering strength at 0 degrees grazing angle, and SS is the sea state, WS is the wind speed, and WH is the save height. Only the sea state, wind speed, or wave height need be specified.

16. ENTER SS0, SS FOR STANDARD SCATTERING MODELS

OPTIONAL For bottom reverberation SS0 is the scattering strength at 0 degrees grazing angle, and SS is the scattering strength at 90 degrees grazing angle.

17. ENTER FILE NAME OF RECEIVER CONTOURS FROM RTHETA

OPTIONAL If a quasi-monostatic or bistatic run is specified then the output from the RTHETA program for the receiver (for the bottom if bottom reverberation is specified, or surface for surface *reverberation*).

18. DO YOU WISH TO SAVE RESULTS ON OUTPUT FILE

The responses to this question are 1 = Yes, 0 = No.

19. ENTER NAME FOR OUTPUT FILE OF REVERB ENVELOPE

OPTIONAL This is the file name assigned to the output data file generated by the program. This file contains information that is necessary to execute the ACTENV program when reverberation is required.

20. ENTER FILE NAME FOR OUTPUT OF VERT REVERB DIST

OPTIONAL This is the file name assigned to the output data file generated by the program. This file contains the vertical arrival structure in a binary output format.

Inputs for Program ACTENV

This section describes the inputs for program ACTENV. ACTENV takes as input reverberation files generated by the program REVERB for the surface and bottom, transmission loss files for the source to target, and receiver to target generated by the program TLVSR, and system input parameters. The output is a print file of the bottom and surface reverberation envelope, and the target echo level, along with a plot of the quantities. The user inputs for ACTENV are listed below as they appear when executing the program.

1. ENTER TITLE FOR THIS RUN

The is an alphanumeric identifier that will appear on the print file and the active performance prediction plot.

2. ENTER NAME FOR OUTPUT PRINT FILE

This is the file name assigned to the output print file generated by the program, it may be any unique valid name.

3. ENTER PING TYPE (1=CW, 2=PULSE, 3=HFM)
   CENTER FREQUENCY, PING DURATION:

Enter the type, the center frequency in hertz, and the ping duration in seconds.

4. ENTER BANDWIDTH

Enter the bandwidth of signal in hertz.

5. ENTER TMIN, TMAX, TAVE:

Enter the minimum and maximum time for which reverberation is to be plotted and the averaging window. An averaging window of 0 implies no averaging.

6. ENTER SOURCE LEVEL PER ELEMENT, NOISE LEVEL,
   RECEIVER DIRECTIVITY INDEX, NO. ARRAY ELEMENTS

Entries are source level per element in dB, the ambient noise level in the band of interest, the receiver directivity index in dB, and the number of source elements.

7. ENTER PLOT PARAMETERS
    ENTER TAXIS(IN), TMIN(SEC), TINC(SEC), TMAX(SEC)
    ENTER YAXIS(IN), YMIN(DB), YINC(DB), YMAX(DB), DELY(DB)

The symbols are:
    TAXIS length of time axis in inches
    TMIN minimum time for which reverberation is plotted in seconds.
    TINC incremental time for labels
    TMAX maximum time for which reverberation is plotted in seconds.
    YAXIS length of reverberation level axis in inches
    YMIN minimum level in dB to be plotted
    YINC increment level (in dB) for labels
    YMAX maximum level in dB to be plotted
    DELY difference between minimum and maximum level (can be set to zero if YMIN, YINC, and YMAX are specified)

8. ENTER SPECTRAL SPREADING LOSS
    FOR SURFACE AND BOTTOM
    If an estimate of spreading loss in the observed spectra for surface an bottom reverberation is known it can be entered here, otherwise enter zeroes for both.

9. ENTER SURFACE REVERBERATION ENVELOPES
    ENTER NOREV, IFWGT
    NOREV is the number of reverberation envelopes (positive number), and IFWGT is either 0 implying that all envelopes are equally weighted, or 1 where envelopes can be weighted by the user.

10. ENTER FILE NAME OF REVERBERATION ENVELOPE
    Enter a data file (binary file) containing reverberation versus time for surface interactions from program REVERB.

11. ENTER WEIGHT FOR THIS ENVELOPE

This question is optional, it is only answered if IFWGT is nonzero.

12. ENTER BOTTOM REVERBERATION ENVELOPES

ENTER NOREV, IFWGT

NOREV is the number of reverberation envelopes (positive number), and IFWGT is either 0 implying that all envelopes are equally weighted, or 1 where envelopes can be weighted by the user.

13. ENTER FILE NAME OF REVERBERATION ENVELOPE

Enter a data file (binary file) containing reverberation versus time for bottom interactions from program REVERB.

14. ENTER WEIGHT FOR THIS ENVELOPE

OPTIONAL Answer only if IFWGT is nonzero.

15. IS TARGET ECHO TO BE INCLUDED? 1=YES, 0=NO

If a target echo calculation is required, and the transmission losses from the receiver (and generally source) to the target have been made then a target echo level can be calculated.

16. ENTER FILE NAME OF TRANSMISSION LOSS FROM THE

TARGET TO THE RECEIVER

This file is a data file created by TLVSR containing the transmission loss from the receiver depth to the target depth.

17. IS A DIFFERENT FILE TO BE USED FOR TRANSMISSION

LOSS FROM THE SOURCE TO THE TARGET? 1=YES, 0=NO

If the run was quasi-monostatic, bistatic, or the source had a beam pattern different from the receiver then the source to target transmission loss must also be used to obtain a correct target echo estimate.

18. ENTER FILE NAME OF TRANSMISSION LOSS FROM   THE

SOURCE TO THE TARGET

This file is a data file created by TLVSR containing the transmission loss from the source depth to the target depth.

19. ENTER RANGE UNITS OF TL VS R FILES: 1=KM, 2=NM

The range units are normally in kilometers when output by the transmission loss module (TLVSR) of RASP.

20. ENTER SLE(DB), SEP(KM)

Enter the source level per element for the source and the source receiver separation (in kilometers).

21. ENTER BRG, TASP:

    BRG =TARGET ASPECT RE RCVR (DGS) - 0 BROADSIDE, +CW

    TASP=TARGET ASPECT RE BEARING LINE (DGS)

        -CW BEARING LINE TO TARGET CENTER LINE

Enter the target-receiver geometry as defined.

22. ENTER TS (RE SQ M) VS ASPECT (0=BOW, 180=STERN)

  ENTER NUMBER OF TS VALUES TO FOLLOW

Enter the number of target strength (relative to a square meter) versus geometric aspect.

23. NOW ENTER 'NTS' [ASPECT(DGS), TS(DB)] PAIRS AT A

    RATE OF ONE PAIR PER LINE

Enter the number of target strengths versus aspect specified in the previous entry, where the aspect is in degrees, and the target strength is in dB per square meter.

APPENDIX B

This appendix gives a list of suggested input values for producing shallow water predictions using this version of the Range Dependent Active System Performance model (RASP). These suggestions are specifically for shallow water, and do not address the more general question of best inputs. The specific recommendations will be given program by program.

TAUNT

TAUNT has no user input other than input and output file names.

PROFIL

PROFIL inputs and output parameters (other than the choice of entering into the program whether the input units are in kilometers, or nautical miles correctly) are significant for shallow water use.

RAYACT

RAYACT has a series of specific input recommendations associated with the execution of this code. The recommendations are:

RMAX(KM) (entry 8) should be set 20 percent more than the maximum range desired.

NODUC (entry 8) should be set to 0

NBB (entry 8) should be set to 98

TMAX(SEC) (entry 8) should be set at 0

BLMAX(dB) (entry 8) should be set to 175

MAXORD (entry 8) should be set to 196

Entry (9) should be set to 1

DELMIN (entry 10) should be set to 5

DELMAX (entry 10) should be set to 25 for water less than 100 meters deep, and 50 for water less than 300 meters.

No of Fans (entry 11) should be set to 5

Entries 11 will then read

-89.5	2.0	-39.5
-39.0	0.5	-19.0
-18.8	0.2	18.8

```
19.0   0.5    39.0
39.5   2.0    89.5
```

RTHETA

No specific recommendations for shallow water runs using RASP are made for RTHETA.

TLVSR

No specific recommendations for shallow water runs using RASP are made for TLVSR.

REVERB

Use the default number for MXHITS (maximum number of hits source), and MXHITR (maximum number of hits receiver) both of which appear in entry 4.

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The Range Dependent Active System Performance model (RASP) has been modified to function at higher frequencies in shallower water than its initial design specification. The major difficulties in the original version of the model were the control of the cubic spline fitting routines to the sound speed points, extension of attenuation coefficients to higher frequencies and the need to interface to Navy standard data bases (or models) for bottom loss calculations. These two areas of difficulty were overcome using a front end sound speed fitting algorithm based on cubic splines under tension to control the oscillations in the spline fits in the model, and subroutines to allow input of standard bottom loss curves.

The resulting modifications to the model created a model capable of predicting range dependent monostatic reverberation (with reasonable accuracy) at frequencies up to 10 kHz. The modifications did not address the broader problem of bistatic range dependent reverberation at high frequencies (or in shallow water), or the problem of "energy splitting loss" on predicted target returns.

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